Dispersion Modeling of Incinerator Stack Emissions at Onyx Environmental Services, Inc. (formerly Trade Waste Incineration)

Sauget, Illinois

Prepared By: Todd D. Ramaly

U.S. Environmental Protection Agency
RCRA Programs Section

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I. Executive Summary

In November 2000, the United States Environmental Protection Agency (U.S. EPA) began an effort to model the dispersion of emissions from the incinerator stacks at the Onyx Environmental Services, Inc. (Onyx) facility located in Sauget, Illinois. This effort was undertaken in order to gauge whether or not the hazardous waste incinerator requirements under the September 30, 1999 Maximum Achievable Control Technology (MACT) Rule (Federal Register Volume 64, page 52827 - 64 FR 52827) would be protective of public health and the environment in the surrounding community. U.S. EPA used dispersion models recommended in the Appendix W of Title 40 of the Code of Federal Regulations Part 51 (40 CFR Part 51) for the modeling effort and based the approach on that of the 1998 Draft Human Health Risk Assessment Protocol (Draft HHRAP) (U.S. EPA 1998).

The results of this first round of modeling were used in preparing preliminary operating conditions for the incinerators under the facility's draft RCRA permit which was provided to Onyx on June 5, 2003 (U.S. EPA 2003). In response to the draft conditions, Onyx commissioned its own dispersion modeling and submitted a report of such on September 8, 2004 (Onyx 2004). U.S. EPA reviewed Onyx's dispersion modeling and found some aspects that were more appropriate for the site and some that were not supportable. Onyx responded by conducting additional stack testing in March of 2005, adding site-specific particle size distributions and mercury speciation for the rotary kiln unit. Onyx submitted updated modeling incorporating the new stack test results in May 2005 (Onyx 2005a).

Incorporating appropriate modeling improvements from Onyx's modeling efforts and the results of the stack testing, U.S. EPA prepared a second round of dispersion modeling in May of 2005. The results were comparable to those generated by Onyx. In October 2005, Onyx submitted yet another version of the modeling differing significantly from earlier versions (Onyx 2005c). The differences were the result of updating the modeling to reflect the new HHRAP which had been finalized with several significant revisions in September of 2005 (U.S. EPA 2005). Onyx incorporated some of the revisions made to the HHRAP.

In April 2006, U.S EPA incorporated recommendations of the finalized HHRAP guidance and appropriate inputs from Onyx's and U.S. EPA's earlier modeling efforts and performed the dispersion modeling documented in this report for use in assessing impacts to public health and the environment in the vicinity of the facility and for the development of operating conditions for the RCRA permit, if any.

II. Facility Information

The Onyx facility, located at #7 Mobile Avenue in Sauget, Illinois, is long and narrow and laid out from the southwest to the northeast on its longest transect (See Figure II-1). Stacks 2 and 3 each serve fixed-hearth dual-chamber incinerators located on the northeastern end of the facility and Stack 4 serves a rotary kiln incinerator located on the southwestern end. The incinerators burn a variety of hazardous wastes. The facility is located in the Mississippi River floodplain and is surrounded by multiple types of land use. Industrial and commercial businesses comprise the immediate vicinity of the facility with residential areas just over a mile away. Nearby waterbodies include the Mississippi River to the west and Frank Holten State Park, which comprises two lakes to the east. The following stack information was submitted by Onyx in its latest modeling report (Onyx 2005c).

Parameter	Stack 2	Stack 3	Stack 4
Source	fixed-hearth dual-chamber incinerators		rotary kiln
Coordinates*	745314.456m E 4275912.275m N	745342.392m E 4275958.041m N	744979.822m E 4275204.979m N
Base Elevation	126.19 meters	126.19 meters	126.49 meters
Stack Height	27.432 meters	27.432 meters	30.48 meters
Stack Diameter	0.6858 meters	0.6858 meters	1.2192 meters
Stack Gas Temperature	463 °Kelvin	463 °Kelvin	481 °Kelvin
Stack Gas Exit Velocity	20.2 meters/second	20.2 meters/second	20.4 meters/second
Emission Rate**	1 gram/second	1 gram/second	1 gram/second

* The coordinates appear to be based on the Universal Transverse Mercatur (UTM) projection of the 1983 North American Datum (NAD83).

** 1 gram/second is an assumption called *unit emission* that simplifies modeling. Actual emission rates or regulatory limits can be applied to the results of modeling a *unit emission* rate after dispersion modeling.

Figure I-1 Site Location Map - Onyx Environmental Services Inc., Sauget, Illinois

Map Source: USGS Digital Raster Graphics (DRGs) at 1:24K scale
compressed into a mosaic MrSID file

III. Meteorological Data

In November 2000, U.S. EPA obtained and prepared five years of hourly meteorological data in the vicinity of the Onyx facility for use in the dispersion modeling. A draft report describing the source data, input assumptions, and how the data was processed is included in Attachment 1. The report includes the original meteorological data processing as well as additional revisions to the meteorological processing made in May 2005.

Onyx's consultant also prepared five years of hourly meteorological data for use in dispersion modeling. U.S EPA noted a number of differences between U.S. EPA's original air modeling and that described in Onyx's report. Attributes of Onyx's modeling that differed with U.S. EPA's original approach, but were based on site-specific information and consistent with the Draft HHRAP, were adopted by U.S. EPA for the dispersion modeling described herein. These instances will be described in detail in subsequent sections where appropriate.

Ultimately, Onyx's meteorological data remained different from U.S. EPA's data in several respects (for example, U.S EPA combined upper air data from Salem and Peoria, Illinois for the modeling while Onyx used data from Monett, Missouri). Before further investigating these differences, U.S. EPA tested the dispersion model for sensitivity to the meteorological data by running the dispersion model for a select group of sensitive receptors (primarily the lakes at Frank Holten State Park). U.S. EPA discovered that total deposition of particle bound or vapor contaminants did not significantly change between meteorological data files (See Table III-1). Total deposition of vapor from all stacks combined averaged six percent higher using the Onyx meteorological data. Differences in total deposition of particle bound contaminants from Stack 4 between meteorological data files were less than one percent. The final dispersion modeling described herein was prepared using Onyx's meteorological data.

Table III-1 Deposition Rate Comparisons – U.S. EPA Modeling with Varying Input Options

Meteorological Data Source	Particle Data Source	Total Particle Bound Deposition – All Stacks	Total Vapor Deposition – All Stacks	Total Particle Bound Deposition – Stack 2
U.S. EPA	Stack 4	0.00681	0.0176	
Onyx	Stack 4	0.00680	0.0186	0.0024
Onyx	U.S. EPA HHRAP			0.0012

Note: 1) All deposition values in grams/square meter/year
2) Deposition rates here are from provisional modeling runs and differ slightly from the final modeling run summarized in the table at the end of the report.

A. Anemometer Height

This is the height of the met station tower above the ground surface. The instrument tower at Lambert Field, St. Louis, Missouri, station number 13994, for the period 1984-1989 was 6.096 meters (20ft) above the ground surface. Onyx's modeling initially used a value of 10 meters for the anemometer height, which corresponds to the current station height. However, at the time of the measurements used for the dispersion modeling, the height was 6.096 meters. Subsequent meteorological data files prepared by Onyx, including those used in the latest U.S. EPA modeling use the correct value.

B. Surface Roughness Length at Measurement Site

Surface roughness height—also referred to as (aerodynamic) surface roughness length—is the height above the ground at which the wind speed goes to zero. Surface roughness affects the height above local ground level that a particle moves from the ambient air flow above the ground (for example in the plume) into a "captured" deposition region near the ground. That is, ISCST3 assumes the particle is deposited to the ground at some point above the actual land surface, based on surface roughness height. Surface roughness height is defined by individual elements on the landscape, such as trees and buildings. The surface roughness over a given area reflects man-made and natural obstructions, and general surface features. The effective surface roughness length has been estimated for a number of surface conditions. U.S. EPA originally used a value of 0.04, which was an average of all seasonal values for grassland to approximate an airport location. Onyx proposed using 0.10 meters (corresponding to grassland during the summer) which the Final HHRAP recommends if you are using National Weather Service surface meteorological data. The final version of meteorological data used in the dispersion modeling used the Final HHRAP recommended value of 0.10 meters.

C. Surface Roughness Length at the Modeled Site

The surface roughness length at the modeled site is a measure of how high above the ground surface particles in a plume will transition from plume flow to gravitational deposition. U.S. EPA originally used a value of 1.0 meter corresponding to that of an urban area (Draft HHRAP). Onyx applied a more site-specific approach, following a Draft HHRAP recommendation to divide the area within 3 kilometers of the facility into a number of compass point directions and estimate an overall surface roughness based on surrounding land use and wind direction frequencies for each compass-point direction. In this manner, Onyx calculated a site-specific surface roughness length of 0.62 meters. U.S. EPA conducted an independent calculation using digital land use/land cover maps which were revised manually taking into account a 2002 aerial photo of the area available on the internet. U.S. EPA obtained the United States Geologic Survey (USGS) land use/land cover map for St. Louis, Missouri from the <http://www.webgis.com> website. The 2002 aerial photo was obtained from the <http://www.terraserver.microsoft.com> website. The adjustment was made manually using graph paper to assign land use to the areas within a 3-kilometer radius of the facility. Attachment 2 contains the figures and spreadsheet output of the calculation. U.S. EPA's calculated site-specific surface roughness length of 0.60 meters was similar to that calculated by Onyx. The current modeling is based on Onyx's calculated value of 0.62 meters.

D. Minimum Monin-Obukhov Length

U.S. EPA originally based this parameter (pertaining to atmospheric stability) at 50 meters for an urban area. Subsequently, U.S. EPA agreed to use the Onyx recommended value, setting the minimum Monin-Obukhov Length to 75 meters, the average value for compact residential/industrial and commercial (19-40 story) buildings.

E. Noon Time Albedo

Albedo (the fraction of incoming solar radiation reflected back into the atmosphere) is used in calculating the heat balance at the surface of the earth and is used to adjust the Monin-Obukhov Length on an hourly basis. The noon time albedo is the value of albedo at midday. U.S. EPA originally used a value of 0.18, corresponding to the average of all seasonal values for urban land use. Onyx applied the approach used for site-specific surface roughness to noon time albedo for different land uses taken from Table 3-5, Albedo of Natural Ground Covers for Land Use Types and Seasons, in HHRAP. In this way, Onyx calculated a noon-time albedo of 0.22. U.S. EPA applied the same approach and estimated noon-time albedo at 0.26. Since the values are similar and the HHRAP indicates dispersion modeling results are not particularly sensitive to this parameter, U.S. EPA agreed to use the Onyx-suggested value of 0.22. A sensitivity analysis conducted by U.S. EPA Region 6 showed that variations in noon time albedo had only slight impacts on dry deposition and no effect on air concentrations or wet deposition (U.S. EPA 1997)

F. Bowen Ratio

The Bowen ratio is the ratio of the sensible heat flux to the evaporative or latent heat flux at the ground surface. U.S. EPA initially used a Bowen ratio of 1.625 (an average of all seasonal values for an urban area). The HHRAP recommends a Bowen ratio of 2.0 for urban areas where annual rainfall exceeds 20 inches. Onyx used a value of 2.0 and the meteorological data used for the current modeling uses this value. The sensitivity analysis conducted by U.S. EPA Region 6 showed that variations in Bowen ratio had only slight impacts on dry deposition and no effect on air concentrations or wet deposition (U.S. EPA 1997).

G. Fraction of Net Radiation Absorbed at the Ground

Also used for calculating hourly values of Monin-Obukhov length, fraction of net radiation absorbed at the ground is the last component of radiative heat balance. U.S. EPA and Onyx both used a value of 0.27 for urban areas, as recommended by HHRAP. The U.S. EPA sensitivity analysis showed that dispersion modeling results were unaffected by variations in the fraction of net radiation absorbed at the ground (U.S. EPA 1997).

H. Anthropogenic Heat Flux

Anthropogenic heat is the surface heating caused by human activity, including automobiles and heating systems. It is used to calculate hourly L values (Monin-Obukhov lengths). The HHRAP gives a table of values of anthropogenic heat flux for a variety of cities around the world. U.S EPA originally applied a linear regression to all the cities in the table located between 34 and 64 North latitude assuming that anthropogenic heat flux was dependent on population density. Using the population density for St. Louis (177 person/square kilometer), U.S. EPA calculated a value of 5 Watts/square meter for anthropogenic heat flux. Onyx used a value of 20 Watts/square meter which is also consistent with the HHRAP recommendation for large urban areas. The current modeling used the HHRAP recommended value of 20 Watts/square meter. The U.S. EPA sensitivity analysis showed that dispersion modeling results were unaffected by variations in anthropogenic heat flux (U.S. EPA 1997).

I. Incoming Solar Radiation and Leaf Area Index

Incoming solar radiation and leaf area index are used by the dispersion model to calculate a varying dry vapor deposition velocity, a key parameter for evaluating dry vapor deposition. The latest version of HHRAP recommends evaluating dry vapor deposition for mercury using the TOXICS model option in the dispersion model. The option allows the user to enter a constant dry vapor deposition velocity or let the model perform complex calculations to derive the velocity. Even though U.S EPA and Onyx both used a constant dry vapor deposition velocity, as recommended in HHRAP, the meteorological data file must be formatted to include columns for incoming solar radiation and leaf area index or the TOXICS model option for dry vapor deposition will not run. For all model runs calculating dry vapor deposition, two additional columns of blank or zero values were added to the final processed meteorological data file.

J. Pre-processed Meteorological File

The surface weather data from the National Weather Service weather station at Lambert Field, St. Louis, Missouri was combined by Onyx with upper air data from Monett, Missouri and the parameters above in order to create one combined pre-processed data file. Onyx did so for each of five years and ultimately performed five individual sets of dispersion modeling. Jeff Sprague, of the Illinois Environmental Protection Agency (IEPA), combined Onyx's yearly meteorological files into one concatenated file for a 5-year period. This file was used in the current version of dispersion modeling with the exception of the vapor runs wherein placeholder columns were added for incoming solar radiation and leaf area index.

IV. Study Area

A. Receptor Grid

U.S. EPA modeled dispersion of stack emissions over a 20 kilometer by 20 kilometer area (just over 154 square miles) surrounding the facility. Receptor locations were defined every 100 meters to a distance of four kilometers from the center of the facility (a point set halfway between Stacks 2-3 and Stack 4). Additional receptors were defined every 500 meters to a distance of 10 kilometers from the facility. See Figure IV-1 for the receptor grid.

Figure IV.-1 Receptor Grid

The receptor grid was prepared using AERMOD-View version 5.1, a windows-based interface for running U.S.EPA approved dispersion models developed by Lakes Environmental Software of Waterloo, Ontario.

B. Terrain

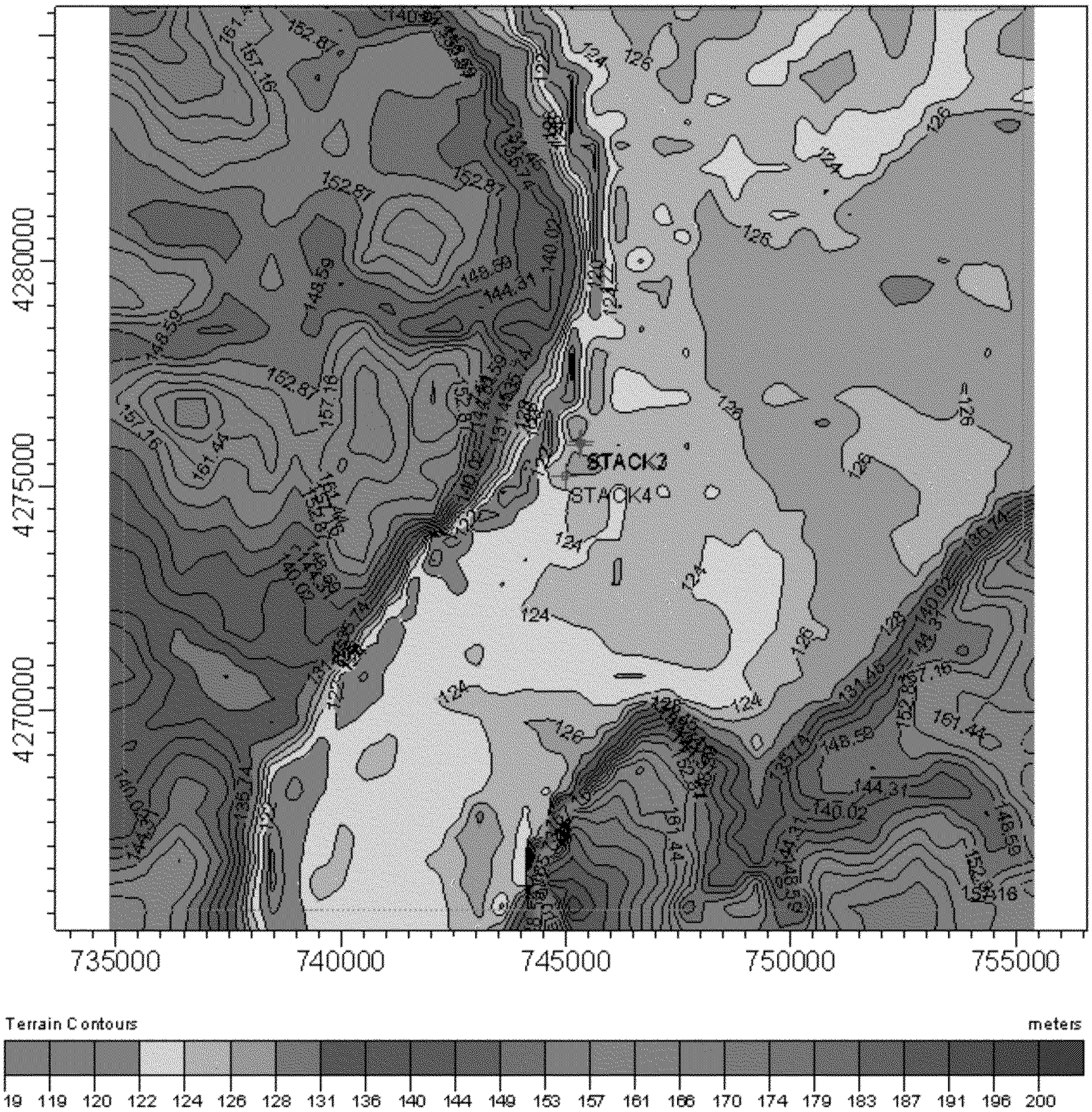
Elevated terrain in the vicinity of the stacks can have a significant impact on the results of air modeling. Onyx's stacks are located on Mississippi River bottomland with nearby bluffs rising as much as 150 feet (44 meters) above the top of Onyx's highest stack. In order to properly handle terrain effects, each receptor point must have a corresponding elevation.

USGS 7.5 Minute Digital Elevation Models (DEMs) with 30 x 30 meter samples (of elevation) were used to obtain the elevations and were already available on the Agency's server. The following specific DEMs were used: Cahokia, IL; Clayton, MO; French Village, IL; Granite City, IL; Monks Mound, IL; and Webster Grove, IL. The Clayton, French Village, and Monks Mound DEMs were found to be in a different projection than the default projection selected for the modeling (NAD83).

U.S. EPA used ARCGIS version 8.3 (a computer based Geographical Information System – GIS – developed by ESRI of Redlands, California) to convert the DEMs from the 1927 North American Datum (NAD27) to NAD83. ARCGIS was also used to ensure that elevation values in the DEMs were in the same units (meters). The DEMs were sampled in ARCGIS to derive an elevation for each receptor point. The UTM coordinates of the receptor grid points were combined with their respective elevations into a text file which was used to import elevations into the dispersion model. See Figure IV-2 for elevations in meters within the receptor grid.

PROJECT TITLE:

Figure IV-2 Elevation in Meters



V. Dispersion Modeling

U.S. EPA used the Industrial Source Complex – Short Term model, Version 3 (ISCST3) to model dispersion of stack emissions from the Onyx facility. ISCST3 is a steady-state Gaussian plume model which can be used to assess pollutant concentrations and/or deposition fluxes from a wide variety of sources associated with an industrial source complex. The model was embedded within AERMOD-View which was used for the current modeling runs.

A. Partitioning of Pollutant into Different Phases

Hazardous constituents are assumed to be emitted and dispersed from the stack in three different ways. Volatile contaminants are expected to be emitted in the vapor phase. Some non-volatile contaminants are expected to be emitted as particles and others are expected to be emitted while absorbed onto the surface of particles (known as particle-bound). The three types of emissions were modeled assuming a unit emission rate (1 gram/second). The dispersion results were scaled to reflect actual emissions or regulatory limits as part of the risk assessment.

B. Particle Emissions

U.S. EPA selected the following model options to model particle emissions:

wet deposition (particles brought to the ground by precipitation);
dry deposition (particles fall to the ground by gravity);
total deposition (wet and dry added together); and
wet and dry plume depletion (deposited particles are subtracted from the plume mass).

In order to run these options, ISCST3 requires a particle size distribution of stack particles and and an estimate of their density. In March of 2005, Onyx conducted stack testing on the rotary kiln and stack 4 for particle size distribution. Stacks 2 and 3, however, were not tested. On October 14, 2005, Onyx submitted a detailed rationale for applying the stack 4 particle data to stacks 2 and 3 based on similarities in air pollution control systems (Onyx 2005b). U.S. EPA ultimately used the particle data from the stack 4 test in part because it resulted in more conservative particle bound deposition (see V.C. below). The following table of particle data is from the October 2005 Onyx Report:

TABLE 3-1
SITE-SPECIFIC PARTICLE SIZE DISTRIBUTION

Geometric Mean Diameter (μm)	Surface Area to Volume Ratio (μm^{-1})	Fraction of Total Mass	Proportion Available Surface Area (μm^{-1})	Fraction of Total Surface Area	Scavenging Rate Coefficient (s^{-1}/mm-h^{-1})	
					Liquid	Ice
0.16	37.91	0.008	0.291	0.082	0.000140	0.000047
0.26	23.37	0.011	0.257	0.073	0.000095	0.000032
0.36	16.85	0.011	0.191	0.054	0.000063	0.000021
0.46	13.17	0.011	0.149	0.042	0.000046	0.000015
0.78	7.70	0.088	0.678	0.192	0.000041	0.000014
1.84	3.26	0.370	1.207	0.343	0.000120	0.000040
3.83	1.57	0.445	0.696	0.198	0.000260	0.000087
6.22	0.97	0.056	0.054	0.015	0.000439	0.000146

Table V-1 Onyx Environmental Services Rotary Kiln and Fixed Hearth Incinerators Human Health Risk Assessment Report, October 2005, Franklin Engineering Group, Inc.

C. Particle Bound Emissions

U.S. EPA selected the same modeling options for the particle bound emissions as were selected for particle emissions:

wet deposition (particles brought to the ground by precipitation);
dry deposition (particles fall to the ground by gravity);
total deposition (wet and dry added together); and
wet and dry plume depletion (deposited particles are subtracted from the plume mass).

The amount of a particle bound pollutant present on a given particle is assumed to be directly proportional to surface area since the contaminant is absorbed to the surface. In order to account for this, HHRAP recommends that the particle size distribution be adjusted for relative particle surface area assuming the particles are spherical. The column in Table V-1 labeled *Fraction of Total Surface Area* is based on this adjustment and is entered as the mass fraction for particle bound contaminants.

Based on the March 2005 stack 4 sampling and analysis for particle size distribution and mercury speciation and the detailed rationale submitted in October, Onyx recommended applying the stack 4 particle data to stacks 2 and 3. U.S. EPA believes there are still too many differences in the design and operation of the incinerators (rotary kiln versus dual-chamber/fixed hearth for example) to completely accept this rationale. U.S. EPA tested stack 2 and 3 particle bound deposition results using stack 4 particle data and an example of particle data from HHRAP consistent with combustion facilities equipped with either electrostatic precipitators or fabric filters. The site-specific particle size distribution (adjusted for surface area) from stack 4 resulted in higher total deposition rates at the Lakes at Frank Holten State Park (the critical receptor location for mercury emissions) than the example particle size distribution in HHRAP. In the absence of stack-specific data for stacks 2 and 3, U.S. EPA used the particle data which resulted in higher deposition at the lakes, the stack 4 data, for the current round of modeling.

D. Vapor Emissions

U.S. EPA originally modeled only wet deposition of vapor. The finalized HHRAP included a protocol for modeling dry deposition as well. The new protocol, using the TOXICS model option in ISCST3, is run with some chemical specific data. Since mercury emissions are the primary concern and no other volatile emissions were risk drivers, the new dry vapor deposition modeling was focused on emissions of divalent mercury vapor. To run the model, HHRAP recommends that a constant dry vapor deposition velocity be entered. According to HHRAP, a default value of 2.9 centimeters/second for divalent mercury can be used. U.S. EPA found the approach acceptable and attempted to model dry vapor deposition based on input files prepared by Onyx. It was discovered that these files contained a unit error. ISCST3 requires that the deposition velocity be entered in meters/second whereas the guidance refers to centimeters/second. The Onyx input files were prepared with a value of 2.9 as opposed to the correct value of 0.029. U.S. EPA made the correction for this round of modeling. The correction resulted in a decrease of vapor deposition at the Lakes of Frank Holten State Park. U.S. EPA attempted to evaluate possible site specific dry vapor deposition velocities, however, it became apparent that the default value would be slightly more conservative and U.S. EPA retained the Onyx suggested value of 2.9 centimeters/second (entered as 0.029 meters/second).

E. Dispersion Coefficients

ISCST3 requires the user select rural or urban dispersion coefficients. HHRAP recommends that the selection be based on surrounding land use. Urban land use is typically defined by land use that has less than 35% vegetative cover. Many different land use types are then divided into urban and rural on this basis. As recommended by HHRAP, the surrounding land use is considered urban if it is greater than 50% of the total. Onyx conducted this procedure and concluded that the land use was close to 50% urban, making it difficult to assign the dispersion coefficients. Onyx agreed to evaluate both conditions for all of its modeling runs. U.S. EPA independently conducted a similar analysis and concluded the area was urban (57%). U.S. EPA further reviewed the land use upwind of the stacks from the perspective of the Lakes at Frank Holten State Park. For the purpose of dispersion coefficients, and other parameters that influence the wind profile, it is recommended that the upwind fetch be used to determine the value, especially for elevated sources like stacks. Essentially, the plume behavior is assumed to be more dependent upon the profile of the wind arriving at the stack from upwind so the upwind land use is used for these determinations. U.S. EPA determined that the upwind land use (to the west) was decidedly urban. Therefore, the current modeling runs were based on urban dispersion coefficients.

F. Input and Output

As stated previously, U.S. EPA prepared the modeling input files based on those provided by Onyx. A new receptor grid was generated and terrain was reimported. The only other change was the correction of the dry vapor deposition velocity as described in V.D. above. The model generated 1-hour and annual plotfiles for air concentration, wet deposition, dry deposition, and total deposition each for vapor, particle and particle bound. The files are included on a CD in attachment 3. The following table demonstrates the changes in air concentration and deposition estimates as the modeling was revised and corrected over time. The results are focused on the lakes and Frank Holten State Park since the risk assessment was most sensitive to mercury impacts through contaminated fish consumption.

Average Annual Air Concentrations and Deposition Fluxes for 11 locations over the 2 lakes at Frank Holten State Park.

Modeling Date	Stack 4				Stack 2 or 3[α]			
	Particle-Bound		Vapor		Particle-Bound		Vapor	
	Air Concentration ($\mu g/m^3$)	Total Deposition ($g/m^2/yr$)	Air Concentration ($\mu g/m^3$)	Total Deposition ($g/m^2/yr$)	Air Concentration ($\mu g/m^3$)	Total Deposition ($g/m^2/yr$)	Air Concentration ($\mu g/m^3$)	Total Deposition ($g/m^2/yr$)
January 2001	0.013	0.0013	0.0133	0.00035	0.009	0.00585	0.01122	0.00052
June 2005	0.0089	0.0023	0.0094	0.00042	0.0106	0.0016	0.011	0.00048
October 2005					0.0104[β]	0.00250[β]	0.01077	0.00047
					0.0104[γ]	0.00156[γ]		
April 2006	0.0096	0.0021	0.0062	0.0058	0.0111	0.00246	0.00694	0.0065

α results from stacks 2 and 3 are considered comparable because each serve nearly identically designed and operated incinerators and are located only 54 meters apart

β based on stack 4 particle data

γ based on HHRAP example particle data

VI. References

Onyx, 2004, *Onyx Environmental Services Rotary Kiln and Fixed Hearth Incinerators, Screening Level Human Health Risk Assessment Report*, Onyx Environmental Services, Inc., September 8.

Onyx, 2005a, *Onyx Environmental Services Rotary Kiln and Fixed Hearth Incinerators, Screening Level Human Health Risk Assessment Report*, Onyx Environmental Services, Inc., May.

Onyx, 2005b, Correspondence with T. Ramaly, U.S. EPA via electronic mail with attached document *Determination of Appropriate Particle Size Distribution and Mercury Speciation to be Utilized for the Fixed Hearth and Rotary Kiln Incinerators*, David Klarich, Onyx Environmental Services, Inc., October 14.

Onyx, 2005c, *Onyx Environmental Services Rotary Kiln and Fixed Hearth Incinerators, Screening Level Human Health Risk Assessment Report-Revised*, Onyx Environmental Services, Inc., October 27.

U.S. EPA, 1997, *Model Parameter Sensitivity Analysis*, U.S. EPA Region 6 Center for Combustion Science and Engineering, Dallas, Texas, May 23.

U.S. EPA, 1998, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, Peer Review Draft, Office of Solid Waste and Emergency Response, EPA530-D-98-001A, July.

U.S. EPA, 2003, Letter to Onyx with attached draft permit, U.S. EPA, R5, Waste Management Branch, June 5.

U.S. EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, Office of Solid Waste and Emergency Response, EPA530-R-05-006, September.

Attachment 1

TWI-incinerator, Sauget, Illinois
Air Modeling

TWI-incinerator, Sauget, Illinois
Air Modeling

Creating met data files for TWI

April 2000

Downloaded Samson files for St. Louis (Lambert Field) for 1985-1989

Stl-85.dat
Stl-86.dat
Stl-87.dat
Stl-88.dat
Stl-89.dat

Downloaded SCRAM upper air files from Salem, Illinois for 1985-1987

03879-85.txt
03879-86.txt
03879-87.txt

Downloaded SCRAM upper air files from Peoria, Greater Peoria Airport for 1988-1989

14842-88.txt
14842-89.txt

November 2000

1) Filled in missing data point in Stl-85.dat - new file Stl-85A.dat
5/19/85 0600hrs - missing dew point - extrapolated 0400-0700hrs - 10.0*C

2) Prepared TWI85.met file using RAMMET-View using Stl-85A.dat and 03879-85.txt

Options for wet deposition:

anemometer height	=	6.096m
Monin-Obukhov length	=	50m (urban)
Surface Roughness Length (measurement site)	=	0.04m (average of all seasonal grassland values to approximate an airport)
Surface Roughness Length (application site)	=	1.00m (urban)
Noon-time Albedo	=	0.18 (average of all seasonal urban values)
Bowen Ratio	=	1.625 (average of all seasonal urban values under average conditions)
Anthropogenic Heat Flux	=	5 W/m^2 (linear regression of population density vs. flux for locations of mid to high latitudes)

The St. Louis metropolitan area has a population reported by the U.S. Census Bureau of 2,444,099 and a population density of 177 persons per km^2. The population density was input to a linear regression of the flux and population density values provided as examples. Hong Kong and Singapore were not used as they appeared to be outliers in this comparison. The remaining dataset comprised cities within 34 to 64 N latitude.

Fraction of Net Radiation Absorbed at Ground = 0.27 (urban)

3) Filled in missing data points in Stl-86.dat - new file Stl-86A.dat
2/1/86 0100hrs - missing ceiling height - extrapolated 2400-0200hrs - 1145m
2/22/86 1300hrs - missing ceiling height - extrapolated 1100-1500hrs - 77777m

4) Prepared TWI86.met file using RAMMET-View using Stl-86A.dat and 03879-86.txt. Same options for wet deposition as for 1985.

5) Filled in missing data points in Stl-87.dat - new file Stl-87B.dat
12/30/87 2400hrs - 12/31/87 2400hrs - missing wind speed and wind direction - extrapolated linearly from 12/30/87 1100hrs - 1/1/88 1200hrs (no other pattern, daily or otherwise apparent)
12/31/87 2400hrs - missing dew point - extrapolated 12/29/87 - 1/2/88 - 9.5*C
12/31/87 2400hrs - missing visibility - extrapolated 2300hrs - 1/1/88 0100hrs - 24.1 km
12/31/87 2400hrs - missing ceiling height - extrapolated 2300hrs - 1/1/88 0200hrs - 77777m

6) Prepared TWI87.met file using RAMMET-View using Stl-87B.dat and 03879-87.txt. Same options for wet deposition as for 1985.

7) Filled in missing data points in Stl-88.dat - new file Stl-88A.dat
12/31/88 2400hrs - missing wind direction - extrapolated 2000hrs - 1/1/89 0300hrs - 298*
12/31/88 2400hrs - missing wind speed - extrapolated 2100hrs - 1/1/89 0300hrs - 2.5m/s
12/31/88 2400hrs - missing dew point - extrapolated 2300hrs - 1/1/89 0100hrs - 0.9*C
12/31/88 2400hrs - missing visibility - extrapolated (logarithmic) 2000hrs - 1/1/88 0400hrs - 2.6 km
12/31/88 2400hrs - missing ceiling height - extrapolated 2000-2300hrs - 90m (low ceiling gave way quickly to clear skies by 0100 1/1/89. . . couldn't extrapolate. Other trends in weather data seemed to indicate that the weather change happened after 2400 based on visually examining graphs of the data, therefore, the clearing sky was also assumed to happen after 2400hrs)

8) Prepared TWI88.met file using RAMMET-View using Stl-88A.dat and 14842-88.txt. Same options for wet deposition as for 1985.

9) Filled in missing data points in Stl-89.dat - new file Stl-89A.dat
12/31/89 2400hrs - missing wind direction - extrapolated 1900-2300hrs - 237*
12/31/89 2400hrs - missing wind speed - extrapolated 1900-2300hrs - 3.5m/s
12/31/89 2400hrs - missing dew point - extrapolated 1900-2300hrs - -1.9*C
12/31/89 2400hrs - missing visibility - set equal to 2300hrs (no trend noticed) - 24.1 km
12/31/89 2400hrs - missing ceiling height - extrapolated 1900-2300hrs - 1349m

10) Prepared TWI89.met file using RAMMET-View using Stl-89A.dat and 14842-89.txt. Same options for wet deposition as for 1985.

11) Re-prepared met files for 1988 and 1989 changing the station location number in the upper air files from Greater Peoria Airport, Peoria, Illinois to match the Salem, Illinois upper air files. RAMMET-View would not combine the five years into one file if the same upper air

stations hadn't been used throughout. Upper air files 14842-88.txt and 14842-89.txt were changed to 03879A88.txt and 03879A89.txt, respectively.

12) A five-year met file, TWI85-89.met, was created by a RAMMET-View utility from TWI85.met, TWI86.met, TWI87.met, TWI88A.met, and TWI89A.met.

May 2005

Based on information provided by Onyx/TWI, including more site specific met processing information, the MET data was updated for new modeling runs. The met data was reviewed again for missing data and re-processed with the following parameters changed from those originally used in step 2) from November 2000 above:

Monin-Obukhov length was changed from 50m (urban) to 75m (average of urban - 50m and commercial - 100m)

Surface Roughness Length (measurement site) was changed from 0.04m (average of all seasonal grassland values to approximate an airport) to 0.10m (HHRAP recommendation for airports)

Surface Roughness Length (application site) was changed from 1.00m (urban) to 0.62m based on surrounding land use (Onyx/TWI referred to HHRAP methodology).

Noon-time Albedo was changed from 0.18 (average of all seasonal urban values) to 0.22 based on surrounding land use (Onyx/TWI referred to HHRAP methodology).

Bowen Ratio was changed from 1.625 (average of all seasonal urban values under average conditions) to 2.0 (Onyx/TWI referred to HHRAP methodology).

Anthropogenic Heat Flux was changed from 5 W/m^2 (linear regression of population density vs. flux for locations of mid to high latitudes) to 20 W/m^2 (HHRAP default for urban areas).

1) Surface and upper air data for 1985, Stl-85.dat and 03879-85.txt, were checked for missing data using using Rammet-View version 4.8, a Meteorological Pre-Processor developed by Lakes Environmental Software of Waterloo, Ontario. The met files were checked for missing data using Rammet View's "grid-preview" feature. The "grid-preview" feature allows the user to review the data and sort the columns numerically, so that blanks or a field of nines (commonly used to designate missing data) could be identified. Missing data was identified and remedied as follows (in accordance with *Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models*, Atkinson, Dennis, and Russell F. Lee, July 7, 1992). No critical missing data were identified. The surface and upper air files for 1985 were combined into combined met file <NewTWI85.met>.

2) Surface and upper air data for 1986, Stl-86.dat and 03879-86.txt were checked for missing data in the same manner and two data points were missing. Ceiling height for 0100hrs, 2/1/86 was filled in with the ceiling height from the preceding hour, 1,070m, since cloud cover was greater than nine tenths. Ceiling height for 1300hrs, 2/22/86 was filled in with the ceiling height representing unlimited ceiling, 77,777m, since cloud cover was less than five tenths. The updated surface file was labeled <Stl-86B.dat> and the combined processed met file <NewTWI86.met> was generated from the surface and upper air files.

3) All wind speeds and wind directions on 12/31/87 were missing from the surface data file. U.S. EPA decided to try to find another complete year rather than try to fill in so many missing hours. Accordingly U.S. EPA downloaded the Samson file, <13994_84.sam>, already converted to ASCII format, from the WebMet web site <http://www.webmet.com/> for the St. Louis (Lambert Field) Airport, station number 13994 for 1984. U.S. EPA obtained the upper air file, <14842-84.txt> from the WebMet web site <http://www.webmet.com/> for the Greater Peoria Airport, Peoria, Illinois, station number 14842 for 1984 since the Salem site data was limited to 1985 through 1987. A check using Rammet-View revealed no missing critical data from either file. All station information within the Peoria upper air file were changed to match the station ID at Salem, Illinois in order to avoid problems when combining the whole 5 years of met data. The upper air file was also renamed <03879A84.txt> and was combined with <13994_84.sam> into the processed file <NewTWI84.met>.

4) Missing data for 1988 was filled in the same manner as originally described above except that the ceiling height for 2400 hrs, 12/31/88 was filled in with the ceiling height from the preceding hour since cloud cover was greater than nine tenths. The updated surface file was labeled <Stl-88B.dat> and the combined processed met file <NewTWI88.met> was generated from the surface and upper air files. Note, the upper air file for 1988 was for data collected at the Greater Peoria Airport, Peoria, Illinois, station number 14842 since the Salem site data was limited to 1985 through 1987. All station information within the Peoria upper air file were changed to match the station ID at Salem, Illinois in order to avoid problems when combining the whole 5 years of met data. The upper air file was also renamed <03879A88.txt> before being processed with the surface file.

5) The existing missing data remedies completed for the 1989 files completed in November 2000 were retained as is. A new met file <NewTWI89.met> was generated from the updated files <Stl-89A.dat> and <03879A89.txt>. Note that the upper air data was collected at the Greater Peoria Airport, Peoria, Illinois, station number 14842, since the Salem site data was limited to 1985 through 1987. All station information within the Peoria upper air file were changed to match the station ID at Salem, Illinois in order to avoid problems when combining the whole 5 years of met data.

6) The processed met data from 1984, 1985, 1986, 1988, and 1989 were combined into one 5-year file, <TWI8489.met>.

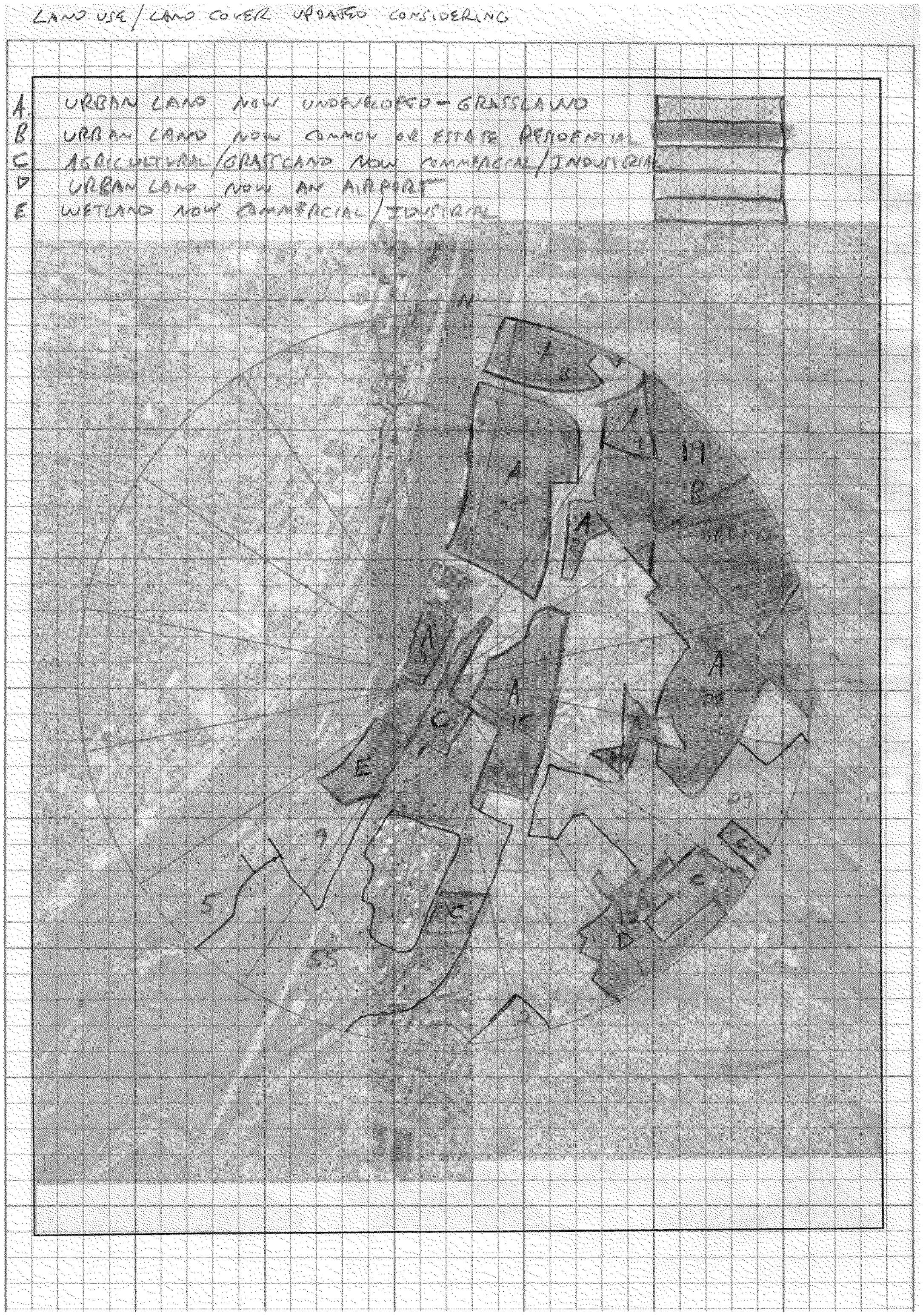
Attachment 2

Independent Calculation of Site-Specific Surface Roughness Length
Figures and Spreadsheet

Title: Land Use/Land Cover

Legend:	pink	urban, commercial, or industrial areas
	yellow	agricultural
	blue	water
	green striped	wetland
	green	deciduous forest
	brown	barren land

2002 *Urban Areas* Aerial Photo from < http://www.terraserver.microsoft.com>



Modified land use/land cover based on 2002 aerial photo and superimposed with a 3-kilometer radius circle divided into 16 compass point directions.

Onyx/TWI Surface Roughness, Noon Time Albedo

Using Land Use/Land Cover updated by Urban Areas Aerial Photo

http://www.terraserver.microsoft.com

0.161

39.174 blocks per slice

0.04025

surface roughness	annual average			
urban	1	barren land	0.2625	as desert
deciduous forest	0.9	wetland	0.1625	
confirerous forest	1.3	water	0.0001	
agricultural land	0.0725	grassland	0.04025	

compass point direction	urban blocks	percent	forest blocks	percent	agricultural blocks	percent	wetland blocks	percent	barren	percent	water blocks	percent	grassland	percent	total	Compass Point Surface Roughness	Wind Frequency (blowing from)	Compass Point Surface Roughness Weighted for Wind Frequency	
N	14	35.74%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	18	45.95%	7.174	18.31%	39.174	0.36	4.09%	0.0149	
NNE	13.67	34.90%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	25.504	65.10%	39.174	0.38	3.62%	0.0136	
NE	31.17	79.57%	0	0.00%	1	2.55%	0	0.00%	0	0.00%	0	0.00%	7.004	17.88%	39.174	0.80	3.67%	0.0296	
ENE	29.174	74.47%	0	0.00%	1	2.55%	0	0.00%	0	0.00%	0	0.00%	9	22.97%	39.174	0.76	3.03%	0.0229	
E	17.924	45.75%	0	0.00%	0.25	0.64%	0	0.00%	0	0.00%	1	2.55%	20	51.05%	39.174	0.48	4.12%	0.0197	
ESE	12.174	31.08%	0	0.00%	17.5	44.67%	0	0.00%	0	0.00%	0	0.00%	9.5	24.25%	39.174	0.35	6.39%	0.0225	
SE	14.674	37.46%	0	0.00%	12.5	31.91%	0	0.00%	0	0.00%	0	0.00%	12	30.63%	39.174	0.41	7.36%	0.0302	
SSE	28.674	73.20%	0	0.00%	5	12.76%	0	0.00%	0	0.00%	0	0.00%	5.5	14.04%	39.174	0.75	7.85%	0.0586	
S	26.174	66.81%	0	0.00%	13	33.19%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	39.174	0.69	10.06%	0.0696	
SSW	9.674	24.69%	0	0.00%	27.5	70.20%	2	5.11%	0	0.00%	0	0.00%	0	0.00%	39.174	0.31	5.21%	0.0160	
SW	8.174	20.87%	5	12.76%	8	20.42%	9	22.97%	0	0.00%	9	22.97%	0	0.00%	39.174	0.38	5.54%	0.0208	
WSW	22.174	56.60%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	17	43.40%	0	0.00%	39.174	0.57	6.77%	0.0383	
W	34.424	87.87%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	4.5	11.49%	0.25	0.64%	39.174	0.88	6.63%	0.0583	
WNW	34.424	87.87%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	4	10.21%	0.75	1.91%	39.174	0.88	9.23%	0.0812	
NW	34.424	87.87%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	4	10.21%	0.75	1.91%	39.174	0.88	7.30%	0.0642	
NNW	32.174	82.13%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	6	15.32%	1	2.55%	39.174	0.82	4.55%	0.0375	
																	95.42%		
	363.102	57.93%	5	0.80%	85.75	13.68%	11	1.75%	0	0.00%	63.5	10.13%	98.432	15.70%	626.784			0.598	meters
															total blocks			wind frequency weighted surface roughness	

Attachment 3

Air Modeling Files – Electronic Format